

What is claimed is:

1. A method for detecting the presence or concentration of glucose in a sample which may also contain an alpha-hydroxy acid or a beta-diketone, which comprises:

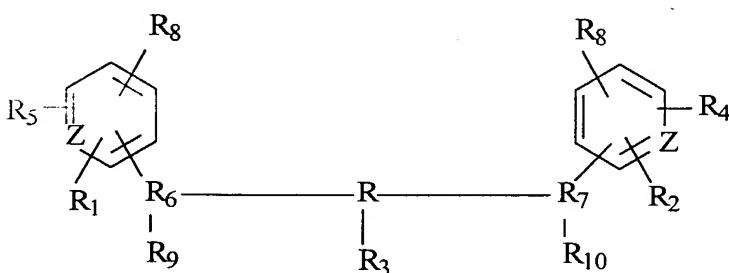
5 a) exposing the sample to a compound having at least two recognition elements for glucose, oriented such that the interaction between the compound and glucose is more stable than the interaction between the compound and the alpha-hydroxy acid or beta-diketone, said compound 10 also containing a detectable moiety having a detectable quality that changes in a concentration-dependent manner when said compound is exposed to glucose in said sample; and

15 b) measuring any change in said detectable quality to thereby determine the presence or concentration of glucose in said sample, wherein the presence of the alpha-hydroxy acid or the beta-diketone does not substantially interfere with said determination.

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2. The method of claim 1, wherein the compound has the following structure:

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wherein:

-R₁ and R₂ are the same or different and are selected from the following: i) hydrogen; ii) a substituent to modify the pKa and hydrolytic stability of the R₈ moiety, iii) a detectable moiety, or iv) a linking group capable of attachment to a solid support or a polymeric matrix, said support or matrix optionally containing a detectable moiety;

5 -R₃ is hydrogen or a linking group capable of attachment to a solid support or a polymeric matrix, said support or matrix optionally containing a detectable moiety;

10 -R₄ and R₅ are the same or different and are selected from the following: i) hydrogen, ii) a substituent to modify the pKa and hydrolytic stability of the R₈ moiety, iii) a detectable moiety, or iv) a linking group capable of attachment to a solid support or a polymeric matrix, said support or matrix optionally containing a detectable moiety;

15 -each Z is independently carbon or nitrogen;

20 -R₆ and R₇ are the same or different and are i) linking groups having from zero to ten contiguous or branched carbon and/or heteroatoms, or ii) a linking group capable of attachment to a solid support or a polymeric matrix, said support or matrix optionally containing a detectable moiety;

25 -R is selected from the following: i) an aliphatic and/or aromatic spacer containing from 1 to 10 contiguous atoms selected from the group consisting of carbon, oxygen, nitrogen, sulfur and phosphorus, ii) a detectable moiety, or iii) a linking group capable of attachment to a solid support or a polymeric matrix, said support or matrix optionally containing a detectable moiety;

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-each R₈ is the same or different and is a moiety capable of interaction with the vicinal diol groups present in glucose; and

5 -R₉ and R₁₀ are the same or different, and are i) hydrogen, ii) a detectable moiety, iii) a group which is a) a linking group capable of attachment to a solid support or a polymeric matrix, said support or matrix optionally containing a detectable moiety, and/or b)

10 includes a functional group capable of altering the physical properties of the compound; with the proviso that the indicator compound contains at least one detectable moiety associated therewith.

15 3. The method of claim 2, wherein R₈ is selected from the group consisting of boronic acid, boronate ion, arsenious acid, arsenite ion, telluric acid, tellurate ion, germanic acid, germanate ion, and combinations thereof.

20 4. The method of claim 3, wherein each R₈ is a boronic acid group.

25 5. The method of claim 2, wherein the compound comprises at least two detectable moieties that are capable of energy transport from one to the other, and wherein said energy transport is modulated by the presence of glucose in the sample.

30 6. The method of claim 2, wherein at least one of R, R₁, R₂, R₄, R₅, R₉ or R₁₀ comprises a fluorophore moiety and further wherein at least one of those groups comprises a quenching moiety, and wherein said fluorophore is either quenched or dequenched when said compound interacts with glucose in the sample.

7. The method of claim 2, wherein the compound comprises a fluorophore, and the fluorescence of said fluorophore is modulated by the interaction of said compound with glucose.

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8. The method of claim 1, wherein the sample is a physiological fluid.

9. The method of claim 8, wherein the physiological fluid is selected from the group consisting of blood, plasma, serum, interstitial fluid, cerebrospinal fluid, urine, saliva, intraocular fluid, lymph, tears, sweat, and physiological buffers.

10 15 10. The method of claim 1, wherein the compound is exposed to the sample in solution.

11. The method of claim 1, wherein the compound is immobilized on or within a solid support.

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12. The method of claim 11, wherein the solid support is a polymeric matrix.

25 13. The method of claim 1, wherein the compound is associated with an implantable device, and wherein step a) takes place *in vivo*.

30 14. The method of claim 2, wherein R is an anthracene residue; R₁, R₂, R₃, R₄ and R₅ are hydrogen; R₆ and R₇ are dimethylamine residues; each R₈ is a boronic acid group; R₉ and R₁₀ are aliphatic carboxylic acid residues; and each Z is carbon.

35 15. The method of claim 14, wherein R₉ and R₁₀ are propionic acid residues.

16. The method of claim 2, wherein R is a hexamethylene residue; R₁, R₂, R₃, R₄ and R₅ are hydrogen; R₆ and R₇ are dimethylamine residues; each R₈ is a boronic acid group; R₉ is a naphthalimide residue; R₁₀ is a dimethylaminobenzyl residue; and each Z is carbon.

17. The method of claim 2, wherein R is an anthracene residue; R₁, R₂, R₃, R₄ and R₅ are hydrogen; R₆ and R₇ are dimethylamine residues; each R₈ is a boronic acid group; R₉ and R₁₀ are the same or different and are selected from the group consisting of a methacrylamidoalkyl residue, a methacroyloxyethoxyalkyl residue, a hydroxyethoxyalkyl residue, and an aminoalkyl residue; and each Z is carbon.

18. The method of claim 2, wherein the compound is selected from the group consisting of:

9-[N-(2-boronobenzyl)-N-[2-(2-methacroyloxyethoxy)-ethylamino]methyl]-10-[N-(2-boronobenzyl)-N-[2-(2-hydroxyethoxy)ethylamino]methyl]anthracene;

9,10-bis[N-(2-boronobenzyl)-N-[3-(propanoyl)amino]-methyl]anthracene;

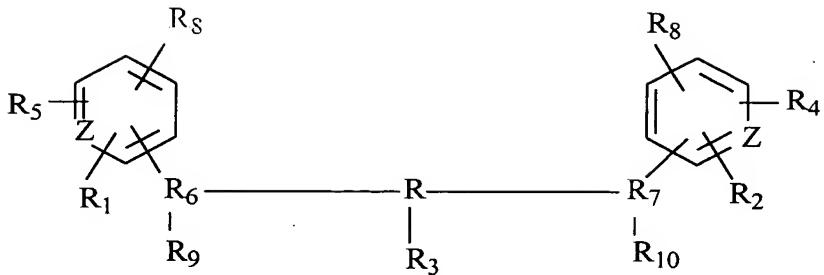
9,10-bis[N-(2-boronobenzyl)-N-[3-(methacrylamido)-propylamino]methylanthracene;

9-[N-(2-boronobenzyl)-N-[3-(methacrylamido)-propylamino]methyl]-10-[N-(2-boronobenzyl)-N-[2-(2-hydroxyethoxy)ethylamino]methyl]anthracene;

9,10-bis[N-(2-boronobenzyl)-N-[2-(2-methacroyloxyethoxy)ethylamino]methyl]anthracene; and

9,10-bis[N-(2-boronobenzyl)-N-[5-aminopentylamino]-methyl]anthracene,
and salts thereof.

19. A compound having the following structure



10 wherein:

- R₁ and R₂ are the same or different and are selected from the following: i) hydrogen; ii) a substituent to modify the pKa and hydrolytic stability of the R₈ moiety, iii) a detectable moiety, or iv) a linking group capable of attachment to a solid support or a polymeric matrix, said support or matrix optionally containing a detectable moiety;
- R₃ is hydrogen or a linking group capable of attachment to a solid support or a polymeric matrix, said support or matrix optionally containing a detectable moiety;
- R₄ and R₅ are the same or different and are selected from the following: i) hydrogen, ii) a substituent to modify the pKa and hydrolytic stability of the R₈ moiety, iii) a detectable moiety, or iv) a linking group capable of attachment to a solid support or a polymeric matrix, said support or matrix optionally containing a detectable moiety;
- each Z is independently carbon or nitrogen;
- R₆ and R₇ are the same or different and are
 - i) linking groups having from zero to ten contiguous or branched carbon and/or heteroatoms, or ii) a linking group capable of attachment to a solid support or a polymeric matrix, said support or matrix optionally containing a detectable moiety;

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-R is selected from the following: i) an aliphatic and/or aromatic spacer containing from 1 to 10 contiguous atoms selected from the group consisting of carbon, oxygen, nitrogen, sulfur and phosphorus,

5 ii) a detectable moiety, or iii) a linking group capable of attachment to a solid support or a polymeric matrix, said support or matrix optionally containing a detectable moiety;

-each R₈ is the same or different and is an

10 optionally protected moiety which when unprotected is capable of interaction with the vicinal diol groups present in glucose; and

-R₉ and R₁₀ are the same or different, and are

15 i) hydrogen, ii) a detectable moiety, iii) a group which is a) a linking group capable of attachment to a solid support or a polymeric matrix, said support or matrix optionally containing a detectable moiety, and/or b)

20 includes a functional group capable of altering the physical properties of the compound;

with the proviso that the indicator compound contains at least one detectable moiety associated therewith.

20. The compound of claim 19, wherein R₈ is selected

25 from the group consisting of boronic acid, boronate ion, arsenious acid, arsenite ion, telluric acid, tellurate ion, germanic acid, germanate ion, all optionally protected, and combinations thereof.

30 21. The compound of claim 20, wherein each R₈ is an optionally protected boronic acid group.

22. The compound of claim 19, wherein the compound comprises a fluorophore, and the fluorescence of said

fluorophore is modulated by the interaction of said compound with glucose.

23. The compound of claim 19, wherein R is an
5 anthracene residue; R₁, R₂, R₃, R₄ and R₅ are hydrogen; R₆ and R₇ are dimethylamine residues; each R₈ is an optionally protected boronic acid group; R₉ and R₁₀ are aliphatic carboxylic acid residues; and each Z is carbon.

10 24. The compound of claim 23, wherein R₉ and R₁₀ are propionic acid residues.

25. The compound of claim 1, wherein R is an
anthracene residue; R₁, R₂, R₃, R₄ and R₅ are hydrogen; R₆
15 and R₇ are dimethylamine residues; each R₈ is an optionally protected boronic acid group; R₉ and R₁₀ are the same or different and are selected from the group consisting of a methacrylamidoalkyl residue, a methacroyloxyethoxyalkyl residue, a hydroxyethoxyalkyl residue, and an aminoalkyl residue; and each Z is carbon.

20 26. The compound of claim 19, wherein the compound is selected from the group consisting of:

25 9-[N-[2-(5,5-dimethylborinan-2-yl)benzyl]-N-[2-(2-methacroyloxyethoxy)ethylamino]methyl]-10-[N-[2-(5,5-dimethylborinan-2-yl)benzyl]-N-[2-(2-hydroxyethoxy)ethylamino]-methyl]anthracene;
9-[N-(2-boronobenzyl)-N-[2-(2-methacroyloxyethoxy)-ethylamino]methyl]-10-[N-(2-boronobenzyl)-N-[2-(2-hydroxyethoxy)ethylamino]methyl]anthracene;
30 9,10-bis[N-(2-boronobenzyl)-N-[3-(propanoyl)amino]-methyl]anthracene;
9,10-bis[N-[2-(5,5-dimethylborinan-2-yl)benzyl]-N-[3-(methacrylamido)propylamino]methylanthracene;

9,10-bis[N-(2-boronobenzyl)-N-[3-(methacrylamido)-propylamino]methylanthracene;

5 9-[N-[2-(5,5-dimethylborinan-2-yl)benzyl]-N-[3-(methacrylamido)propylamino]methyl]-10-[N-[2-(5,5-dimethylborinan-2-yl)benzyl]-N-[2-(2-hydroxyethoxy)-ethylamino]methyl]anthracene;

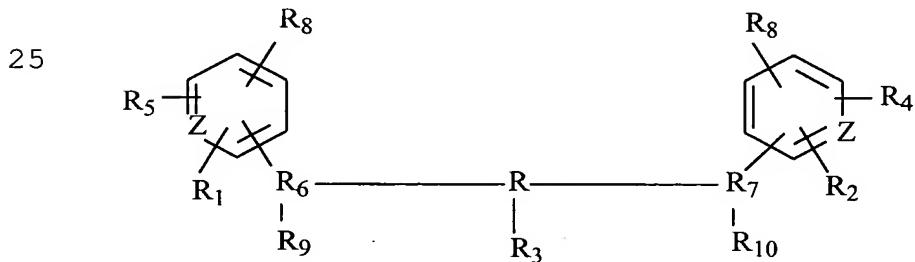
10 9-[N-(2-boronobenzyl)-N-[3-(methacrylamido)propylamino]methyl]-10-[N-(2-boronobenzyl)-N-[2-(2-hydroxyethoxy)ethylamino]methyl]anthracene;

15 9,10-bis[N-[2-(5,5-dimethylborinan-2-yl)benzyl]-N-[2-(2-methacroyloxyethoxy)ethylamino]methyl]anthracene;

20 9,10-bis[N-(2-boronobenzyl)-N-[2-(2-methacroyloxyethoxy)ethylamino]methyl]anthracene; and

25 9,10-bis[N-(2-boronobenzyl)-N-[5-aminopentylamino]methyl]anthracene,
and salts thereof.

27. A detection system for detecting the presence or concentration of glucose in a sample which may also contain an alpha-hydroxy acid or a beta-diketone, which comprises a compound having the following structure



wherein:

35 -R₁ and R₂ are the same or different and are selected from the following: i) hydrogen; ii) a substituent to modify the pKa and hydrolytic stability of the R₈

moiety, iii) a detectable moiety, or iv) a linking group capable of attachment to a solid support or a polymeric matrix, said support or matrix optionally containing a detectable moiety;

5 -R₃ is hydrogen or a linking group capable of attachment to a solid support or a polymeric matrix, said support or matrix optionally containing a detectable moiety;

10 -R₄ and R₅ are the same or different and are selected from the following: i) hydrogen, ii) a substituent to modify the pKa and hydrolytic stability of the R₈ moiety, iii) a detectable moiety, or iv) a linking group capable of attachment to a solid support or a polymeric matrix, said support or matrix optionally containing a detectable moiety;

15 -each Z is independently carbon or nitrogen;

20 -R₆ and R₇ are the same or different and are i) linking groups having from zero to ten contiguous or branched carbon and/or heteroatoms, or ii) a linking group capable of attachment to a solid support or a polymeric matrix, said support or matrix optionally containing a detectable moiety;

25 -R is selected from the following: i) an aliphatic and/or aromatic spacer containing from 1 to 10 contiguous atoms selected from the group consisting of carbon, oxygen, nitrogen, sulfur and phosphorus, ii) a detectable moiety, or iii) a linking group capable of attachment to a solid support or a polymeric matrix, said support or matrix optionally containing a detectable moiety;

30 -each R₈ is the same or different and is an optionally protected moiety which when unprotected is capable of interaction with the vicinal diol groups present in glucose; and

-R₉ and R₁₀ are the same or different, and are
i) hydrogen, ii) a detectable moiety, iii) a
group which is a) a linking group capable of
attachment to a solid support or a polymeric
matrix, said support or matrix optionally
containing a detectable moiety, and/or b)
includes a functional group capable of altering
the physical properties of the compound;
with the proviso that the indicator compound contains at
least one detectable moiety associated therewith.

28. The detection system of claim 27, wherein R₈ is
selected from the group consisting of boronic acid,
boronate ion, arsenious acid, arsenite ion, telluric
acid, tellurate ion, germanic acid, germanate ion, all
optionally protected, and combinations thereof.

29. The detection system of claim 28, wherein each
R₈ is an optionally protected boronic acid group.

30. The detection system of claim 27, wherein the
compound comprises a fluorophore, and the fluorescence of
said fluorophore is modulated by the interaction of said
compound with glucose.

31. The detection system of claim 27, wherein R is
an anthracene residue; R₁, R₂, R₃, R₄ and R₅ are hydrogen;
R₆ and R₇ are dimethylamine residues; each R₈ is an
optionally protected boronic acid group; R₉ and R₁₀ are
aliphatic carboxylic acid residues; and each Z is carbon.

32. The detection system of claim 31, wherein R₉ and
R₁₀ are propionic acid residues.

33. The detection system of claim 27, wherein R is an anthracene residue; R₁, R₂, R₃, R₄ and R₅ are hydrogen; R₆ and R₇ are dimethylamine residues; each R₈ is a boronic acid group; R₉ and R₁₀ are the same or different and are selected from the group consisting of a methacrylamidoalkyl residue, a methacroyloxyethoxyalkyl residue, a hydroxyethoxyalkyl residue, and an aminoalkyl residue; and each Z is carbon.

10 34. The detection system of claim 27, wherein the compound is selected from the group consisting of:

9-[N-[2-(5,5-dimethylborinan-2-yl)benzyl]-N-[2-(2-methacroyloxyethoxy)ethylamino]methyl]-10-[N-[2-(5,5-dimethylborinan-2-yl)benzyl]-N-[2-(2-hydroxyethoxy)ethylamino]-methyl]anthracene;

9-[N-(2-boronobenzyl)-N-[2-(2-methacroyloxyethoxy)-ethylamino]methyl]-10-[N-(2-boronobenzyl)-N-[2-(2-hydroxyethoxy)ethylamino]methyl]anthracene;

9,10-bis[N-(2-boronobenzyl)-N-[3-(propanoyl)amino]-methyl]anthracene;

9,10-bis[N-[2-(5,5-dimethylborinan-2-yl)benzyl]-N-[3-(methacrylamido)propylamino]methylanthracene;

9,10-bis[N-(2-boronobenzyl)-N-[3-(methacrylamido)-propylamino]methylanthracene;

9-[N-[2-(5,5-dimethylborinan-2-yl)benzyl]-N-[3-(methacrylamido)propylamino]methyl]-10-[N-[2-(5,5-dimethylborinan-2-yl)benzyl]-N-[2-(2-hydroxyethoxy)-ethylamino]methyl]anthracene;

9-[N-(2-boronobenzyl)-N-[3-(methacrylamido)-propylamino]methyl]-10-[N-(2-boronobenzyl)-N-[2-(2-hydroxyethoxy)ethylamino]methyl]anthracene;

9,10-bis[N-[2-(5,5-dimethylborinan-2-yl)benzyl]-N-[2-(2-methacroyloxyethoxy)ethylamino]methyl]anthracene;

9,10-bis[N-(2-boronobenzyl)-N-[2-(2-methacroyloxyethoxy)ethylamino]methyl]anthracene; and

9,10-bis[N-(2-boronobenzyl)-N-[5-aminopentylamino]-methyl]anthracene,
and salts thereof.